Journal of the Lepidopterists' Society
38(4), 1984, 310–316

OBSERVATIONS ON THE BIONOMICS OF *HELIOTHIS PHYLOXIPHAGA* (NOCTUIDAE) ON CLUSTER TARWEED IN SOUTHEASTERN WASHINGTON[1]

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ABSTRACT. The bionomics and brief descriptions of the life stages of *Heliothis phyloxiphaga* Grote & Robinson, a noctuid associate of the composite weed, *Madia glomerata* Hook., are presented. The moth was univoltine in southeastern Washington, with peak adult populations appearing during late July. Eggs were deposited on immature involucres, and the first- and second-stage larvae fed within the involucres on the developing achenes, while later stage larvae consumed bracts, flowers, and leaves. Pupation occurred in the soil from late August to early October. Under laboratory conditions, the life cycle of the moth from egg to adult required ca. 52 days.

The entomofaunas of many plants indigenous to North America are either unknown or inadequately characterized. Typically, little in-depth biological information is available on specific associates. This is particularly true for cluster or stinking tarweed, *Madia glomerata* Hook. (Compositae: Madiinae), a weed of the western United States and Canada.

The plant is an erect, 30–100 cm tall, yellow-flowered, summer annual that often forms dense stands in rangeland, pastures, along roadsides or ruderal areas (Dennis, 1980). Numerous stalked glands on the stems, leaves, and floral capitula produce a nauseating, tar-scented, sticky exudate that is readily transferred to clothing or animals upon contact. *M. glomerata* is rarely grazed by livestock and thus has virtually no forage value. The weed is allelopathic and prevents establishment or reduces growth of various desirable forbs and grasses (Carnahan & Hull, 1962).

In southeastern Washington, cluster tarweed was consistently attacked by the noctuid *Heliothis phyloxiphaga* Grote & Robinson. Although much biological information is available for the more important agricultural pest species of *Heliothis* such as *H. virescens* (F.) and *H. zea* (Boddie) (Hardwick, 1965), very little is known about the bionomics of the non-economically important species including *H. phyloxiphaga*. This lack of information prompted the present investigation.

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[1] Scientific paper no. 6727. Work conducted under projects 0335 and 0582, Washington State University, Agricultural Research Center, Pullman.

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METHODS

Studies on the biology of *H. phyloxiphaga* were conducted in the laboratory and correlated with observations made in the field at several sites within a 15 km radius of Pullman (Whitman County) in southeastern Washington from 1979–83. Laboratory rearings, initiated from field-collected eggs and larvae, were maintained at 20–25°C, 40–50% RH, and 14 L:10 D hour regime. Eggs were confined to 10.0 × 1.5 cm plastic petri dishes lined with moistened paper towelling until hatching occurred. Newly emerged to mid-fifth stage larvae were reared individually in petri dishes provisioned with a moistened paper substrate and sufficient host plant material. The paper and food were replaced daily. Nearly mature larvae were transferred to ventilated 7.0 × 8.5 × 3.5 cm clear plastic boxes filled with sandy loam soil for pupation. Pupae remained in the cages until adult eclosion.

Emergent moths were sexed, paired, and placed in cylindrical (15 cm diam × 30 cm high) translucent plastic cages ventilated apically with fine mesh saran screen. A 2 dr shell vial filled with a 20% honey-water solution and plugged with cotton dental wicking along with several freshly-excised, field-collected *M. glomerata* floral shoots inserted through the Parafilm® seal of a water-filled receptacle were placed in the cage and replenished as needed. Nocturnal observation of adults was accomplished under red illumination (simulated darkness).

RESULTS

Distribution. *H. phyloxiphaga* has a distribution that ranges from the Mississippi River west to California, north to the Canadian provinces of Alberta and British Columbia, and south to Mexico, with additional records from Illinois, Massachusetts, and New York (Forbes, 1954; Crumb, 1956).

Host plants. Based upon an examination of pertinent literature, the moth has a broad host range. In addition to *M. glomerata,* the following larval food plants have been noted by Grote and Robinson (1867), Crumb (1926, 1956), Forbes (1954), Tietz (1972), and T. F. Watson (pers. comm., Univ. Arizona): COMPOSITAE: *Achillea millefolium* L., *Balsamorhiza* sp., *Chaenactis douglasii* (Hook.) H. & A., *Erigeron divergens* T. & G., *Grindelia camporum* Greene, *G. robusta* Nutt., *G. squarrosa* (Pursh) Dunal, *Hemizonia congesta* DC., *Lactuca sativa* L., *Machaeranthera canescens* (Pursh) Gray, *Parthenium argentatum* Gray; GERANIACEAE: *Erodium cicutarium* (L.); GRAMINEAE: grasses; IRIDACEAE: *Gladiolus* sp.; LEGUMINOSAE: *Lathyrus* sp.,

Medicago sativa L.; POLEMONIACEAE: *Gilia aggregata* Spreng., *Phlox* sp.; ROSACEAE: *Fragaria* sp.; SCROPHULARIACEAE: *Antirrhinum* sp.; and SOLANACEAE: *Schizanthus* sp.

Description of stages. Egg. The pearly pale yellow hemispherical egg averaged 0.63 ± 0.25 mm in height and 0.69 ± 0.03 mm in diameter (n = 25). The chorion was sculptured with numerous prominent ribs that radiated from a nipple-like micropyle positioned at the apical pole. A reddish purple band developed in the micropylar half of the egg within 72 h of deposition, and as embryogenesis proceeded the entire egg assumed a brownish grey color.

Larva. The first-stage larva was creamy grey with a blackish brown head capsule and prothoracic shield. The second-stage larva differed little except for a somewhat paler head capsule, prothoracic shield, and greenish grey color. Definitive maculation and coloring become evident in the third-stage larva and are maintained in fourth- and fifth-stage larvae. The fifth-stage larva had a greenish brown to beige head capsule mottled with brown and a light green or olive-green body. An excellent description of the mature larva is given by Crumb (1926, 1956) and abbreviated descriptions occur in Lange and Michelbacher (1937) and Stahler (1939). Lange and Michelbacher (1937) also included a photograph of the mature larva and pictured the larval chaetotaxy.

The body lengths of ten first- through fifth-stage larvae averaged 2.72 ± 0.48 mm, 5.62 ± 0.75 mm, 12.09 ± 3.89 mm, 19.56 ± 1.29 mm, and 28.15 ± 3.30 mm, respectively. First- and second-stage larvae experienced an average increase in length of 47% between successive molts, whereas, third- to fifth-stage larvae grew 65%. Mean cast head capsule widths of the five instars were 0.32 ± 0.02 mm, 0.52 ± 0.05 mm, 0.90 ± 0.10 mm, 1.61 ± 0.06 mm, and 2.55 ± 0.16 mm (n = 15), respectively.

Pupa. The pupa was obtect and glossy golden amber when first formed but became chestnut-brown as it matured. In the male, the slit-like genital opening bordered by a pair of tubercles was situated mid-ventrally on the ninth abdominal segment. In the female, the genital aperture occurred on the eighth abdominal segment. The cremaster consisted of two slightly curved, divergent spines arising from the conical apex of the tenth abdominal segment. Lange and Michelbacher (1937) provided a photograph of the pupa. The mean length of 17 pupae was 16.89 ± 3.96 mm.

Adult. Adult *H. phyloxiphaga* males and females are similar in appearance. When viewed from above, the body and forewings are a dull brownish yellow with a distinctive olive-green tinge, the forewings being marked with several brownish black spots and brown to greenish

fawn irregular transverse bands. The maculation of the creamy buff hindwings consisted of a dull black discal spot and a black, broad, transverse marginal band interrupted by a central creamy buff patch. Detailed descriptions of the adult are given by Grote and Robinson (1867) and Forbes (1954). Lange and Michelbacher (1937) included a photograph of a series of adults showing subtle color and maculation variations and also illustrated the male genitalia. The mean body length and alar expanse of 25 adults was 14.5 ± 0.6 mm and 33.0 ± 1.0 mm, respectively.

Life history and habits. In the southernmost portions of its range, *H. phyloxiphaga* may be bivoltine (Lange & Michelbacher, 1937; Forbes, 1954), with first and second generation adults appearing from April–May and July–August, respectively. In Washington the moth was univoltine. Based upon field observations and examination of label data from specimens deposited in the M. T. James Entomology Collection, Washington State University, adult activity commenced in late June and extended to early September, with peak populations being recorded from mid-July to early August. Crumb (1956) reported similar findings regarding seasonal occurrence of the adults.

Adults were not commonly encountered in nature. The moths are inactive during the day and were occasionally observed clinging to stems of dead weeds or grasses and amongst leaf litter, the coloration of the closed forewings blending imperceptibly with the resting substrate, presumably affording the adult protection from predation. If disturbed, adults flew short distances before resettling. Adult feeding was not observed in the field, but individuals readily imbibed the honey-water provided in the laboratory.

Mean longevity of 24 laboratory-reared males was 13.7 ± 6.3 (range 5–30) days; longevity of females was 12.5 ± 8.9 (range 4–29) days. The sex ratio of 44 cultured adults was 1.2:1 (24 males : 20 females).

Mating behavior was not observed for *H. phyloxiphaga* but it is probably similar to that described for *H. virescens* (Lingren et al., 1977) and *H. zea* (Callahan, 1958).

The preoviposition period, from emergence to first deposition of eggs, for six females averaged 6.2 ± 2.3 (range 4–8) days. Based only upon days when these females oviposited, they laid an average of 29.8 ± 26.4 (range 1–130) eggs per day over a 12.0 ± 6.9 (range 4–23) day period, with the majority of eggs being deposited during the first seven days. Total eggs laid per female ranged from 53–536, the average being 282.3 ± 190.6.

Oviposition was generally a crespuscular activity. Plants averaging 40.0 ± 10.8 (range 17.5–62.5) cm in height (n = 125) with terminally developing inflorescences were selected for oviposition purposes. When

an acceptable ovipositional site was encountered by a mated female she momentarily alighted on a cluster of flower heads and rapidly vibrated her wings prior to egg deposition. Wing movement ceased as the female appressed the tip of her abdomen to the outer surface of an involucral or receptacular bract to which she affixed an egg, the deposition process requiring only one or two sec. The female resumed flight and laid additional eggs on the same plant or on nearby plants. In the laboratory, females would often feed and/or rest for brief intervals during the oviposition period. Field observations revealed that females deposited nearly equal numbers of eggs on the bracts of the involucre or receptacle. Of 28 eggs laid on involucres, 16 (57%) were attached to the central head in a cluster, the others being affixed to peripheral heads. Egg distribution on 100 field-examined plants was as follows: 60 had a single egg, 24 had 2 eggs, nine had 3 eggs, four had 4 eggs, five had 2 eggs, and one plant had 6 eggs. Eggs were found in nature from mid-July to the first week in September.

Prior to hatching, the larva assumed a U-shape within the eggshell, with the head and caudal end tightly compressed at the micropylar end. The larva chewed a ragged hole through the chorion in the polar or equatorial region. When the orifice approximated the size of the head capsule, the larva exited by peristaltic contractions of its body. The entire hatching process required ca. 12–15 min. The chorionic remnant was generally not consumed by the neonatal larva. The incubation period of 48 laboratory-laid eggs was 5.4 ± 0.5 days. Viability of these eggs exceeded 98%.

A newly emerged larva initially fed sparingly upon the epidermis and underlying parenchyma cells of the bracts upon which the egg had been laid. Soon thereafter the larva crawled to and chewed a hole through an involucre near its mid-point or base and entered, wherein, it fed upon the developing florets and immature achenes. A sparse, irregular deposition of silk was evident upon and amongst the stalked glands of the infested involucre. The webbing and extruded frass pellets provided concealment for the feeding larva. Each cluster tarweed involucre contained ca. 12 (range 8–20) achenes that were destroyed or damaged by larval feeding. A first- and second-stage larva was each capable of destroying four to five involucres. Attacked involucres shriveled and failed to open. Third- to fifth-stage larvae were external feeders on flowers, involucral and receptacular bracts, and leaves but would not eat achenes approaching maturity. These larvae, especially in dense stands of the weed, moved from plant to plant feeding upon the succulent tissues and defoliating the flowering shoots. Larvae of this age category were highly cannabalistic, and consequently, only a

single larva per plant was found in nature. The green larvae were not easily discernible among foliage and flower heads, their cryptic coloration probably affording a degree of protection from predators. Older larvae, when disturbed, either regurgitated a droplet of green fluid or dropped from the plant to the soil, assumed a coiled posture, and remained motionless for several minutes.

The duration of the first to fifth stadia averaged 4.0 ± 0.3 (range 3–5) days (n = 53), 3.7 ± 0.7 (range 3–5) days (n = 43), 4.0 ± 0.7 (range 3–6) days (n = 34), 6.2 ± 1.0 (range 5–8) days (n = 26), and 7.9 ± 1.0 (range 6–9) days (n = 19), respectively.

The fifth-stage larva stopped feeding during the sixth to ninth day of development. The larva became strongly positively geotactic and descended to the soil and burrowed to a depth of 1.5–4.0 cm. Having reached a suitable depth, the larva constructed an emergence tunnel and elliptical pupal cell. The smooth-walled, sparsely silk-lined chamber averaged 20 mm in length and 10 mm in diam (n = 20). The upward-sloping emergence tunnel was sealed with a loosely fitting plug of silk-bound soil particles.

Upon completion of the cell, the larva contracted to ca. 50% of its former length ($\bar{x}$ = 18.5 ± 2.29 mm; n = 8), assumed a lime green color, and became quiescent. About 24 h later, the prepupal integument ruptured medially along the dorsum of the thorax and the head of the pupa emerged through the slit. The integumental remnant was slid posteriorly by body movement of the pupa and eventually formed a loose mass at the base of the cremaster. Pupal emergence was completed in ca. five min. The duration of the prepupal period, from feeding cessation to pupa formation, was 3.2 ± 0.4 days (n = 20).

The pupa was usually positioned within the cell with the head directed toward the emergence tunnel. If physically disturbed, the pupa slowly rotated its abdomen in a clockwise direction.

In the field, pupation occurred from late August to early October, the pupa overwintering in an obligate diapause state. The pupal period of 59 laboratory-reared, non-diapausing individuals averaged 17.5 ± 2.1 (range 13–23) days.

Adult eclosion was facilitated through fractures in the pupal exuvium, which developed dorsally along the thorax and ventrally near the antennae. The adult then freed itself by alternate expansions and contractions of the abdomen and leverage afforded by the legs. Emergence took place within the pupal cell, and the crumpled winged adult exited through the tunnel to the soil surface where wing expansion and integument hardening was accomplished. Adult emergence was a nocturnal event, occurring between 2100 and 0300 h.

Natural enemies. The anthocorid, *Orius minutus* (L.), was observed feeding on the eggs of *H. phyloxiphaga*. However, the extent to which this predator destroyed eggs was not determined.

An unidentified braconid, a primary solitary larval parasitoid, was responsible for ca. 25% of the late stage larval mortality observed in nature. Intraspecific, internecine combat also contributed to larval mortality as previously noted.

No pupal or adult parasitoidism or predation was observed during the study.

ACKNOWLEDGMENTS

The authors wish to thank R. W. Poole, USDA Systematic Entomology Laboratory, IIBIII, for confirmation of our tentative identification of *H. phyloxiphaga*. We also express appreciation to D. Thompson and L. Walls for their invaluable assistance with field collections and laboratory rearings.

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